INDOOR AIR QUALITY ASSESSMENT

Cold Spring Elementary School
57 Main Street
Belchertown, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
October 2003

Background/Introduction

At the request of Robert LaChance, Director of Facilities, Belchertown Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality at the Cold Spring Elementary School (CSES), 57 Main Street, Belchertown, Massachusetts. Reported concerns of mold and general indoor air quality prompted the assessment. On May 30, 2003, a visit to conduct an indoor air quality assessment was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA. Mr. Feeney was accompanied by Judy Dean, Western Massachusetts American Lung Association, and Mr. LaChance.

The school is a one-story, two-wing, red brick structure built in 1954. It contains general classrooms, cafeteria, main office, teachers' room, and restrooms. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school complex services approximately 320 students in kindergarten and first grade, and has a staff of approximately 30. Tests were taken under normal operating conditions and results appear in Tables 1.

Discussion

It can be seen from Table I that carbon dioxide levels were above 800 parts per million of air (ppm) in five of seventeen areas surveyed, indicating adequate air exchange in most areas of the school at the time of the assessment. Please note that most of the classroom windows were open. Open windows can greatly contribute to reduce carbon dioxide levels. With windows closed during the heating season, carbon dioxide levels would be expected to increase.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the front of the unit. Univents were found deactivated, preventing a continuous source of outside air. In addition, shrubbery located around the perimeter and growing in close proximity to the building was obstructing fresh air intakes (Picture 2). In order for univents to provide fresh air as designed, the units must be activated and allowed to operate. In addition, univent air intakes, diffusers and return vents must remain free of obstructions.

Exhaust ventilation is provided by open holes or "intakes" located along interior classroom walls (Picture 3). The location of these intakes allows them to be easily blocked by stored materials. As with the univents, in order to function properly, exhaust vents must remain free of obstructions.

The storage area on the ground floor appears to have been redesigned to house the "speech" room. Located in this area is an elaborate system of vents connected to an exhaust fan. No other means to introduce fresh air exists. Air is drawn from the hallway through a passive vent. In order for this system to provide air movement during school hours, the exhaust fans must be operating.

Of note is the exhaust ventilation system in the Lunch/All Purpose Room. A single, large opening exists on a wall to the left of the stage. The vent is not connected to a motorized exhaust fan. Exhaust ventilation is created by a heating element within the airshaft. Air warmed by the heating element rises up the airshaft, which then draws air from the Lunch/All Purpose Eoom. This type of ventilation system, commonly known as a gravity exhaust system, cannot exhaust air when the heating system is deactivated. The deactivated vents can create a condition of stale air and allow for odors to linger.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings ranged from 73^{o} F to 78^{o} F, within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature control is difficult without ventilation systems operating as designed. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are commonly experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in classrooms was 41 to 53 percent, within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Of concern were reports of musty odors and respiratory symptoms experienced by occupants residing in the PT Room. The PT Room was created through the erection of a permanent wall behind the stage in the Lunch/All Purpose Room (Picture 4). A number of conditions make the PT Room prone to musty odors:

- The PT Room does not have any source of mechanical ventilation. No HVAC equipment exists in the room. The univents and the gravity exhaust vent of the Lunch/All Purpose Room are physically separated from the PT Room by the permanent wall.
- An openable window is installed within a glass block window system (Picture 5). The current Massachusetts Building Code requires that if a window is the source of ventilation "…[t]he minimum openable area to the outdoors shall be 4 percent of the floor area being ventilated" (SBBRS, 1997; BOCA, 1993). For example, the window of a 10 ft. by 10 ft. room must be openable to a minimum of four ft^2. It is not clear whether the window in this room would be sufficient to provide ventilation for this area.

- The glass block window system makes this room prone to overheating when in direct sunlight. Heat would be expected to linger within this space due to a lack of ventilation.
- Signs of water staining/penetrating from the ceiling to the area behind a permanent wood bookshelf were noted (Picture 6). Efflorescence was noted on the brick wall. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. Brick and mortar are not good mold growth media. In contrast, wood can be a mold growth medium, particularly if repeatedly moistened, without drying.
- Signs of water staining/penetrating below the window block system. This can indicate that moisture is accumulating in the space below the stage floor. The exterior junction between the window block system and the exterior show signs or erosion/deterioration (Picture 7). This can serve as a water penetration pathway.
- The stage area lacks mechanical ventilation. In BEHA's experiences, the majority of stages have some sort of ventilation system (mechanical or passive) that allows for airflow to pass beneath the floor. No means for ventilating the space below the stage floor could be identified. This lack of

ventilation can lead to stagnant air and prevent accumulated water from rapidly evaporating.

- Built-in brick wall planters are located in the Lunch/All Purpose Room next to the stage (Picture 8). These planters are devoid of living plants but are filled with dirt (Picture 9). It could not be determined whether any of these planters have adequate drainage. Plant soil can be a source of particulates, such as mold, which can be a respiratory irritant to some individuals if aerosolized.

The sealing on the back stage area combined with inadequate ventilation of the PT Room and other factors are likely contributing to the musty odors and stale air within this area. These other factors include: a lack of active ventilation provided by the Lunch/All Purpose Room exhaust vent, a lack of air movement below the stage floor and water likely penetrating into the stage area.

Several pathways exist for crawlspace air to migrate into occupied areas. A crawlspace exists under classrooms to provide a chaseway for univent heating pipes. The interiors of univents were randomly examined. Spaces and holes in walls and floors around pipes and within the air handling cabinet were noted (Pictures 10 & 11). These spaces can serve as pathways to draw air, odors and particulates from exterior wall cavities and the crawlspace into classrooms.

A number of means for water to penetrate the building exist. As previously mentioned, caulking around windows appears to be missing, damaged or crumbling in a number of areas (Picture 12). Window seams should be properly sealed to prevent water intrusion and subsequent mold growth.

Shrubbery growing in direct contact with the exterior wall brick was noted along the building foundation (Picture 13). In addition, a garden was planted along the west wall of the south wing, in close proximity to the foundation wall on the uphill side of the building (Picture 14). Shrubbery growing directly against the building can serve as a possible source of water impingement on the exterior curtain. Plants also retain water, thus providing an additional source of water that can penetrate a building. Gardens covered with mulch and shrubbery can also hold water against the foundation of a building. These conditions can produce means for water to penetrate below grade areas, such as basements and crawlspaces. In some cases, roots can work their way into mortar and brickwork causing cracks and fissures. Over time, this process can undermine the integrity of the building envelope by providing a means of water entry into the building through capillary action (Lstiburek & Brennan, 2001).

Plants were noted in several classrooms. In one classroom, planters were placed on top of the univent. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Several classrooms have sinks with a seam between the countertop and wall (Picture 15). If not watertight, water can penetrate through this seam. Water penetration and chronic moisture exposure can cause porous materials to swell and serve as a medium for mold growth.

The school has a tile system that is glued directly to the ceiling (Picture 16). A number of classrooms have ceiling tiles that appear to be water-damaged. Replacement of these ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile, which can result in the aerosolization of particulates. Water-damaged wall plaster and ceiling tiles may provide media for mold and mildew growth and should be replaced after a water leak is discovered and repaired.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. Airflow into the univent is controlled by a pendulum type louver that covers both the fresh air intake and return vents. This configuration requires that two separate filters be installed over the fresh air intake and return vents (Picture 17). While the return vent filter appeared to be replaced regularly, the fresh air intake vent filter was missing in several univents examined. In this condition, unfiltered outdoor air is drawn into the univent. Univent fresh air intakes that are low to the ground can draw pollen, mold spores dirt and other pollutant and distribute these pollutants into classrooms.

Filters installed in univents provide minimal respirable dust filtration. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency should be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by AHUs due to increased resistance, or pressure drop. Prior to any increase of filtration, a ventilation engineer should be evaluated each univent to ascertain whether it can maintain function with more efficient filters.

Cleaning products were found on countertops and in unlocked storage cabinets beneath sinks in a number of classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g. papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Stored food containers that may attract rodents and other pests were noted in some classrooms. One classroom had an ant farm that had a number of ants outside the container (Picture 18). Another classroom had accumulated milk cartons. Food residues in milk cartons and improperly stored foods can be an attractant for pests. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. The reduction/elimination of pathways/food sources that are attracting these insects should be the first step taken to prevent or eliminate this infestation and therefore prevent the use of pesticides.

The teachers' room has a photocopier and a lamination machine. Lamination machines may also be source of waste heat and odors. Photocopiers and laminators may produce odors and other materials that can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

The conditions noted at the CSES raise a number of issues. The combination of the enclosing of the backstage area and the condition of the ventilation system can adversely influence indoor air quality. In view of the findings at the time of the visit, the following recommendations are made:

1) Unblock or create passive ventilation vents for the space beneath the stage. Once created, clean accumulated materials from beneath stage floor.
2) Remove wood shelves from PT Room (Picture 6).
3) Install the fresh air filter in each univent. Change filters as per the manufacture's instructions or more frequently if necessary.
4) Place a fan in the opening of the Lunch/All Purpose Room exhaust vent to direct air up the airshaft, during times of the school year when the heating system is deactivated. This will provide a means for creating airflow and removing accumulating pollutants from this area.
5) Place the exhaust fan for the speech room complex on a timer so it is operating during school hours.
6) Remove dirt from planters in the Lunch/All Purpose Room. Clean and disinfect the planter with an appropriate antimicrobial agent.

7) Seal all holes in the walls of the univent air handling cabinets to limit filter bypass. Double sided, foil faced insulation with adhesive can be applied in a manner to create an airtight seal.

8) Seal walls in the rear of each univent cabinet and floor holes to prevent air draw from the exterior wall cavity and crawlspace, respectively. Seal the seams and holes in the crawlspace access hatches with duct tape.

9) Remove plant from close proximity of univent fresh air intakes.

10) Take steps to prevent prolonged moisture contact with the foundation. These steps may include:

    a) Remove foliage, gardens and mulch to at least five feet away from the foundation.

    b) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, & Brennan, 2001).

    c) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, & Brennan, 2001).

11) Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

12) Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect adjacent areas for water-damage and mold growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed.

13) Remove plants from tops of univents. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Remove foliage to no less than five feet from the foundation/exterior walls.

14) Use the principles of integrated pest management (IPM) to rid the building of pest. A copy of the IPM recommendations from the Massachusetts Department of Food and Agriculture (MDFA, 1996) can be obtained at the following website: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf. Activities that can be used to eliminate pest infestation may include the following activities.

    a) Refrain from using food as components in student artwork.

    b) Rinse out recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.

    c) Remove non-food items that rodents are consuming.

    d) Store foods in tight fitting containers.

    e) Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs are recommended.

    f) Regularly clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment;

g) Examine each room and the exterior walls of the building for means of rodent egress and seal. Holes as small as ¼" are enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (cardboard boxes) where rodents may reside (MDFA, 1996).

15) Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16) Consider adopting the US EPA document, "Tools for Schools", in order to maintain a good indoor air quality environment on the building (US EPA, 2001). The document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1) Consult an HVAC engineering firm. Based on the age, physical deterioration and availability of parts for ventilation components, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system. It is possible that restoration of the current univents in this building is not feasible from a technical standpoint or may be cost prohibitive. If repair is technically not feasible or is cost prohibitive, consideration should be give to replacing the ventilation

system as detailed in the Belchertown Public Schools Five Year Capital Improvement Plan (BPS, 2002).

2) Examine the feasibility of providing mechanical ventilation for the PT Room.

3) Examine the feasibility of installing a mechanical exhaust fan on the airshaft for the Lunch/All Purpose Room.

4) Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth and should be removed. Source of water leaks (e.g., window frames and roof) should be identified and repaired. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.

5) Replace caulking around windows to prevent water-damage and the subsequent colonization of wooden windowsills by mold. Consideration should be given to replacing window systems as detailed in the Belchertown Public Schools Five Year Capital Improvement Plane (BPS, 2002).

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Picture 1

Univent

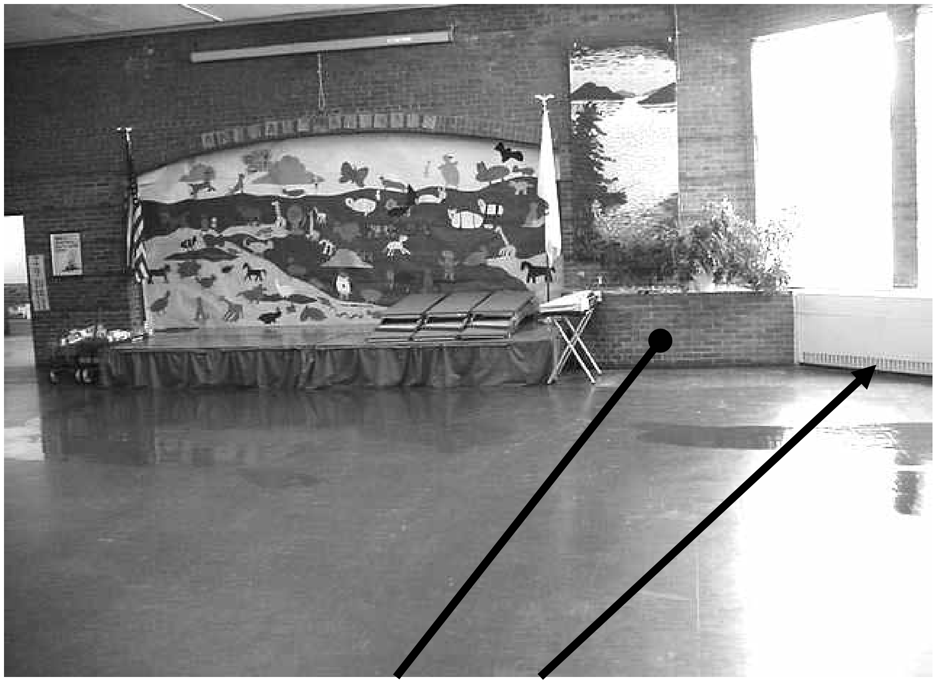
Picture 2

Plants Growing in Close Proximity to Univent Fresh Air Intake

Picture 3

Exhaust Vent

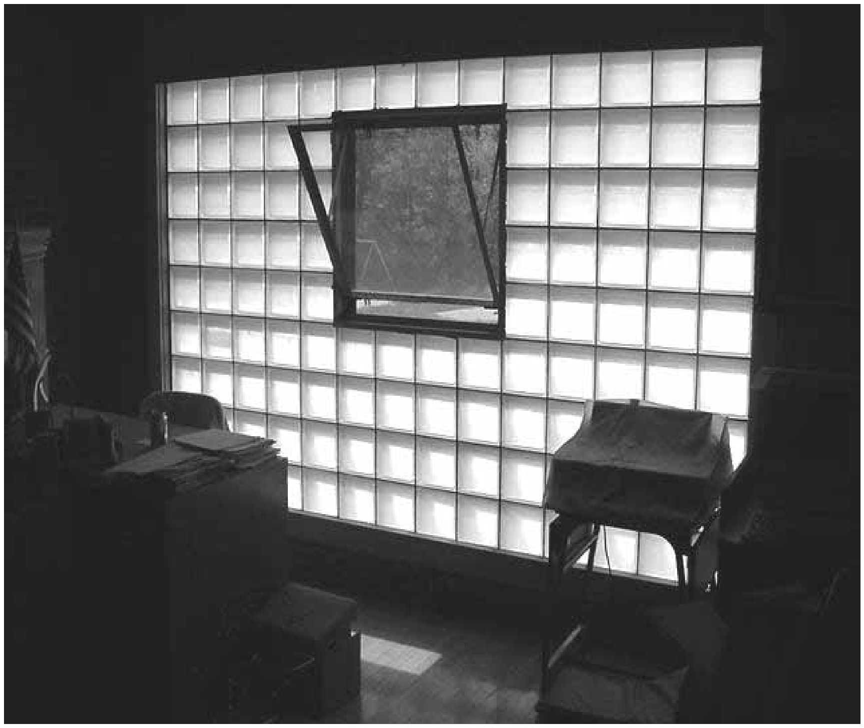
Picture 4



Planter Univent

Permanent Wall Erected on Stage to Create the PT Room, Note Location of Planter and Univent

Picture 5



Window in Glass Block Window System in PT Room

Picture 6

Water Damaged Ceiling and Wall, PT Room

Picture 7

Exterior Junction between the Window Block System and the Exterior Show Signs or Erosion/Deterioration

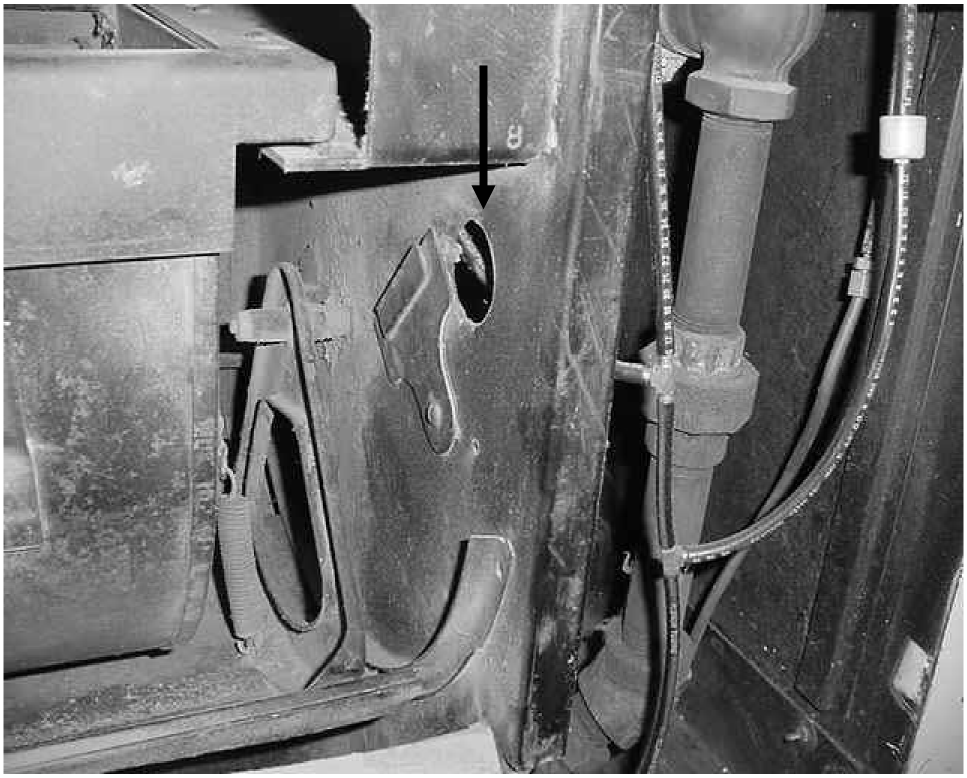
Picture 8

Planter in Lunch/All Purpose Room, Note Univent Location

Picture 9

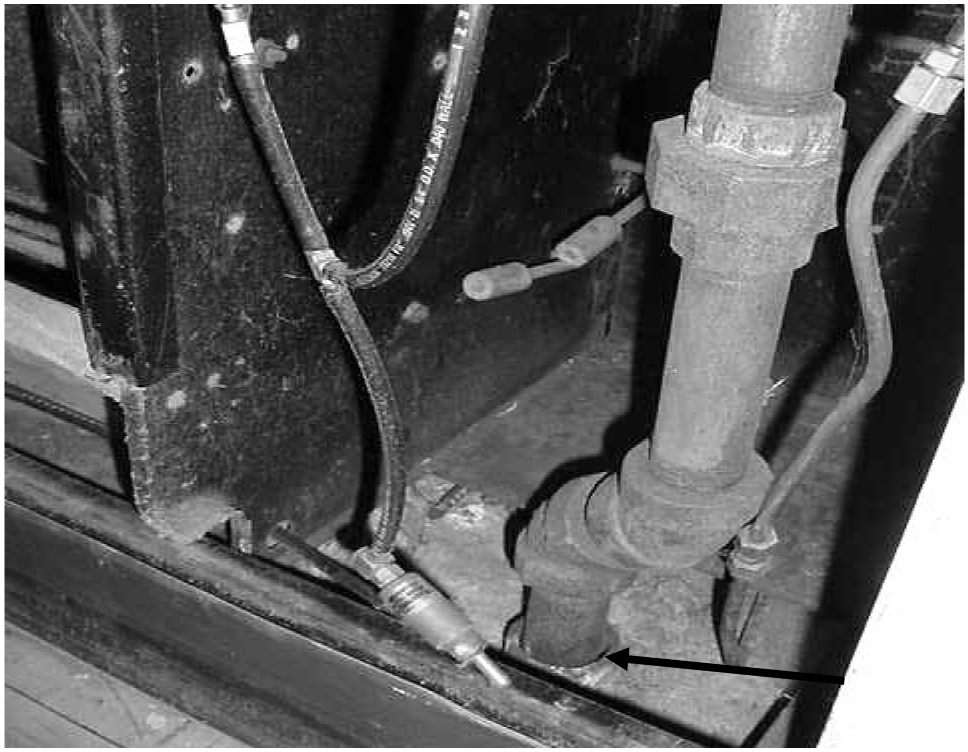
Dirt and Stone in Indoor Planter

Picture 10



Holes within the Air Handling Cabinet

Picture 11



Holes Exist in the Floor for the Univent Heating Pipes

Picture 12

Damaged caulking around window

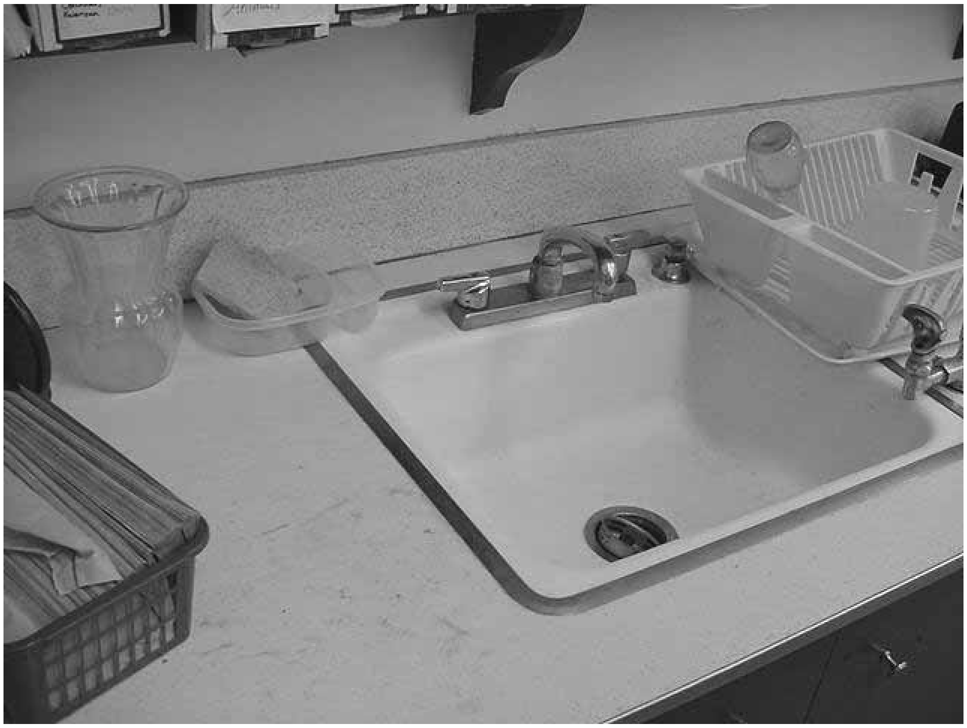
Picture 13

Plants Growing Against Building Foundation

Picture 14

Garden Was Planted Along The West Wall Of The South Wing In Close Proximity To The Foundation Wall On The Uphill Side Of The Building

Picture 15



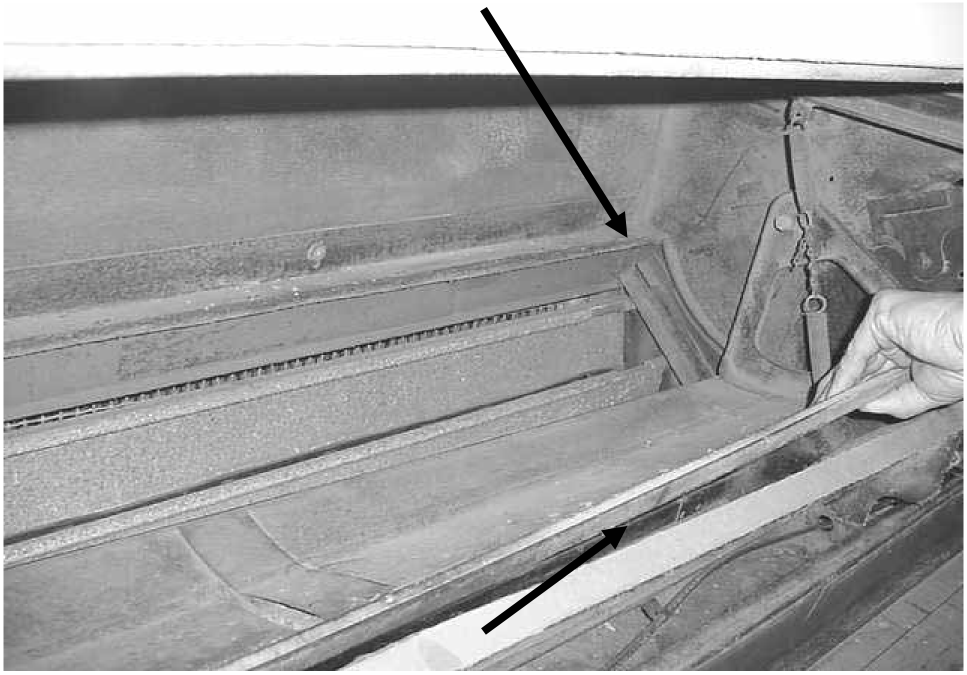
Seam between Countertop and Baseboard

Picture 16

Tile System Glued Directly To the Ceiling, Note Water Stain

Picture 17

Fresh Air Intake Vent Filter Rack



Return Vent Filter

Unfiltered Fresh Air Intake of Univent

Picture 18

Ant Farm on Univent

TABLE 1

Indoor Air Test Results – Cold Springs Elementary School, Belchertown, MA May 30, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	362	75	38					
Room 4	534	74	51	1	Y	N	Y	Clutter
Nurses Office	683	75	54	2	Y	Y	N	Supply off Door open
Room 3	758	74	49	24	Y	Y	Y	3 WD-CT Window open
Room 2	1135	74	52	25	Y	Y	Y	Window/door open, markers Exhaust in closet, clutter
Room 1	558	73	48	4	Y	Y	Y	Window/door open
Teachers' Room	713	75	50	5	Y	N	N	Window/door open, Window-mounted A/C, Photocopier, coke machine, laminator
Room 6	928	78	51	19	Y	Y	Y	Window open Clutter
Room 7	941	77	48	21	Y	Y	Y	2 WD-CT Clutter, window open
PT on enclosed stage	806	76	47	1	Y	N	N	Window open, musty odor, holes in ceiling, water-damaged plaster, efflorescence

*** ppm = parts per million parts of air**
WD-CT = Water damaged ceiling tile

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Cold Springs Elementary School, Belchertown, MA **May 30, 2003**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Cafeteria	790	72	47	50+	Y	N	Y	Plants; efflorescence Exhaust off
Main Office	562	76	45	2	Y	N	N	Photocopier Window open
Speech	671	74	51	1	Y	N	Y	Whiteboard, WD sink, plants, door open; exhaust blocked by table
Room 12	560	75	53	25	Y	Y	Y	Window/door open, dry erase, WD sink, plants
Room 9	902	76	49	20	Y	Y	Y	6 WD-CT, plants, WD sink Exhaust blocked by file cabinet
Room 11	657	77	52	23	Y	Y	Y	Plants Milk cartons, window open
Room 10	566	76	46	20	Y	Y	Y	Window open, WD sink Plants, whiteboard, aquarium
Cafeteria	710	76	48	16	Y	Y		

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